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Methyl bromide alternatives

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Inside This Issue

Loss of Methyl Bromide: Impact on the Strawberry Nursery Industry

Decades ago, growers dreamed of an ideal fumigant that would kill disease organisms without affecting the commodity, leave no harmful residue, not corrode equipment, be effective in low concentrations and short treatment periods, and be moderate in cost and readily available.

Methyl bromide—which is now used throughout the world on more than 100 commodities—comes very close to being that gaseous fumigant. But under the U.S. Clean Air Act, methyl bromide will no longer be available for growers in the United States on January 1, 2001.

One segment of the U.S. economy that will be hardest hit by this fast-approaching ban is the strawberry nursery industry.

"All the strawberry nurseries in California use methyl bromide to fumigate for soilborne pathogens," says Curt Gaines. He is general manager of the Lassen Canyon Nursery in Redding, California, the world's largest commercial strawberry nursery. "Even organic growers use plants from fumigated soils and still maintain their organic status. California growers are responsible for 85 percent of the U.S. strawberry production, and they help supply the international market as well. Most commercial strawberry varieties used internationally come from commercial California nurseries."

According to Gaines, the main purpose of a strawberry nursery is not to just mass produce plants, but to produce those plants with a minimum number of pathogens present. "We must certify to growers, in writing, that our plants are basically pathogen free. Now we can do that because we have the protection of methyl bromide. This chemical, combined with other soil fumigants like chloropicrin, eliminates the chance of nematodes or pathogens like *Verticillium* or *Phytophthora* attacking our plants. We nurserymen are liable to growers for clean plants. Losing methyl bromide poses a risk factor that most of us can't afford."

Nurseries are responsible for their strawberry plants being true to variety, Gaines says. If plants come up with a disease problem that the nursery could have generated, then the nursery must accept liability to the growers.

This newsletter provides information on research for methyl bromide alternatives from USDA, universities, and industry.

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One nursery plant can actually produce 100 million other plants before being eliminated from the California strawberry certification program.

"Lassen Canyon Nursery has been involved with University of California scientists on a fumigation project that has been testing possible alternatives to methyl bromide for seven years. So far, I haven't seen a viable alternative that works as well or as consistently as methyl bromide," he says. "Telone with chloropicrin works fairly well, but the use of Telone is already restricted in California. If we didn't have methyl bromide, most existing nurseries in California would probably be forced out of business. We just couldn't face the potential liability problem."

Gaines is worried about the cumulative effect. Growers may do fairly well with some alternatives for the first year after fumigation. But what about the second year, the third, the fourth, and so on?

Not only do California nurseries supply strawberry plants to growers throughout the United States, but to nurseries in Canada that turn around and supply Florida growers. "We also supply the East Coast with plug and plant production. We supply plants to the Spanish nursery industry, most of Western European countries such as France, Italy, Greece, Morocco, Tunisia, and Portugal, as well as Mexico, Argentina, and other South American countries. In fact, we ship our plants to practically every country in the world except where there are phytosanitary restrictions. These plants come from the same strawberry varieties introduced by scientists at the University of California. The Spanish strawberry industry has been basically designed after the California industry, using California-developed technology," Gaines says.

The loss of methyl bromide will simply shift the strawberry nursery industry to another country that can still use it, he says. "In the first year we used methyl bromide, we increased production by 30 percent. Strawberry plants are in the ground for less than a year, which means that growers must get new, disease-free plants every year. An acre of nursery strawberry plants costs about $20,000 and plants out at about 40 acres of fruit, which can cost the grower about $500,000. And that doesn't even include harvesting costs."

This is just too much of a risk for most growers or nurserymen to face without methyl bromide or a proven alternative.

Tim Nourse, president of Nourse Farms, Inc., in South Deerfield, Massachusetts, agrees that the risk is great. "Our certified plants are the basis for the strawberry growers' livelihood. Their income depends on our plants' being pathogen free."

Nourse Farms is the largest nursery on the East Coast, supplying the East Coast, West Coast, and Midwest, as well as international markets, with certified strawberry and bushberry (including blackberry and raspberry) stock.

"We used to get our certified virus-free stock from the U.S. Department of Agriculture. But since 1980, we've been propagating our own in a lab on our premises," Nourse says.

Nourse Farms now begins the process with tissue-cultured stock (or clones) that has been virus tested and heat treated to eliminate disease problems. "Once we have a clean clone, we take the meristem tissue from that plant to begin the tissue culture propagation process. Once plant tissue is in culture, we make transfers or subcultures every three to five weeks to mass produce the amount of stock required for the certification process. We then transfer plants to the greenhouse to establish roots, getting them ready for field planting." Nourse says.

Methyl bromide is used to maintain these pathogen-free plants, he says. "We've tried other fumigants, but methyl bromide is the most successful and economically viable treatment. I've been in the strawberry nursery business for 30 years and don't see how we can go back to the days of the 1940s and 1950s when we had little understanding of how to control pests like nematodes and soilborne diseases. With today's advanced technology, we have a much better understanding of these pests and know that we must eliminate them. Although some potential alternatives to methyl bromide control nematodes, it's the soil fungal diseases that worry us more."

This is because of the cost. According to Nourse, "Using any of the alternatives available now would substantially increase our costs to meet the zero threshold for nematodes and soilborne diseases that we must meet for growers to feel safe with our plants. It now costs us about $80,000 each year to fumigate our nursery with methyl bromide. To do a comparable job with an alternative would cost substantially more."

Many of the growers in the eastern United States don't fumigate their strawberry fields. "They use crop rotation to control nematodes and

soil fungal diseases. But, eastern and Midwestern growers are fortunate in that they farm other crops besides strawberries and can rotate those crops because of a short growing season and cold weather which affects the growth of soilborne pests and diseases. Growers in California, Florida, the Carolinas, Georgia, and eastern Virginia are more dependent on methyl bromide because a longer growing season creates more disease and pest pressure."

Also, he says, these growers don't have the luxury of a lot of crop rotation. They may rotate a crop of lettuce with their strawberries, but they don't have the option of crops like sweet corn or squash—like eastern and Midwestern growers have—because they may have 100 acres to plant. And that much acreage of the rotation crop may not be economically feasible. Therefore, the grower in a warmer climate ends up planting strawberries on the same land year after year.

"Although we fumigate with methyl bromide, in our own nursery in New England, we still follow a three- to five-year crop rotation plan," says Nourse.

Nourse says that many growers will be forced out of business if more economical alternatives aren't found by 2001, but those who remain will need plants that are certified pathogen free. "We'll be hard pressed to produce those plants economically without methyl bromide."

Tomato Growers Address the Loss of Methyl Bromide

The loss of methyl bromide in 2001 will have a great impact on Florida's tomato growers.

Wayne Hawkins, executive vice president of the Florida Tomato Exchange, says that the ban will wipe out many growers. "We simply won't be able to compete with Mexican growers, who will still be allowed to use methyl bromide for several years after 2001," he says. The Florida Tomato Exchange represents growers who produce 95 percent of the tomatoes grown in central and southern Florida. Crops from these growers constitute about 50 percent of U.S. fresh-market tomatoes.

Hawkins says that since NAFTA was passed, 100 Florida tomato growers have gone out of business and 24 large tomato packing facilities have closed.

"Our growers are cooperating with universities and with the Government in the search to find alternatives to methyl bromide, but so far, we haven't seen any alternative that works nearly as well," says Hawkins. "Our argument is simple: if Florida growers can't use methyl bromide, then our competitors should not be allowed to use it either."

Growers Speak

Paul DiMare is the largest grower of fresh-market tomatoes in the United States. On 6,000 acres located in Florida, California, and South Carolina, he grows peppers, cucumbers, and squash, but primarily tomatoes. DiMare's operation is a mainstay to the economy of south Dade County, Florida.

"We were one of the first growers to use methyl bromide," DiMare says. "Our farming operation is family run and we've been growing vegetables with this chemical since the early 1970s. We started with a mixture of methyl bromide and chloropicrin on old land. This means that the soil had already been farmed 30 or 40 years and was plagued with problems like nematodes and Verticillium and Fusarium wilts. Although we tried several chemicals to solve these problems, the methyl bromide/chloropicrin treatment was the only thing that worked for us."

And, now, decades later, methyl bromide is the only treatment that DiMare uses to maintain production at an economic level that keeps him in the business of growing tomatoes.

"It costs about $6,000 an acre to grow our tomatoes," he says. "We can't afford to sink that kind of money into the earth unless we're confident that we can recoup that cost by producing a profitable crop. Granted, about 5 percent of that cost is for the fumigant, but we couldn't afford to take a chance on risking the other 95 percent unless we had some security. Right now, methyl bromide is our security."

What would DiMare do if methyl bromide were banned today?

"We'd have to quit farming," he says. "Before we started using methyl bromide, we only got about 25 to 30 percent of the tonnage we now get. There's just no way we

could stay in business, because right now there is no commercially available alternative to methyl bromide. And, I don't know of anything that will be available anytime soon. So, realistically, we'd have no choice. We'd go under."

He says a good example of just how effective methyl bromide is comes across loud and clear when the fumigation equipment gets blocked and sometimes skips 100 to 200 feet of soil in a field being treated with methyl bromide. "Of course, we have no way of knowing this at the time, but when that crop matures, it is readily apparent: sickly looking plants that bear little or no fruit."

According to DiMare, he has always been careful about methyl bromide escaping from the soil. "We always had a machine about 20 feet behind the fumigation equipment that was putting down mulch to keep methyl bromide from escaping into the air. In all our years of using this chemical, we've never had a worker affected by escaping fumes."

A little of DiMare's crop goes to Canada, but most of it is marketed in the United States. "'Made in the USA' means a lot to us. We're in stiff competition with Mexican growers, but we're confident that we can meet the needs of U.S. consumers. However, we can't do that if Mexico continues to use methyl bromide when its use is denied us."

John Taylor is a large tomato grower in Florida's Manatee County. Although he doesn't have DiMare's problem of "old land," he nevertheless has problems with soilborne diseases and pests even though he practices crop rotation on his acreage. Taylor also farms in Georgia and Virginia.

"We started using methyl bromide back in the 1970s, but we always put down plastic mulch simultaneously as we fumigated," he says. "I'm not sure that I could make it if methyl bromide were taken away. We've been working with University of Florida scientists for several years now on chemical and other types of alternatives, but nothing has been as effective."

Taylor says that some of the other fumigants work on some problems, but they must be combined with other chemicals to take care of weeds. For production, yield, and quality, nothing compares to methyl bromide.

"Right now, our production, yield, and quality are what helps us keep our heads above water in the competition with California and Mexican growers," Taylor says. "California tomato growers don't have to use plastic tarps because their growing conditions are so different from ours. Their land is arid, so their disease and pest problems are not as significant as ours. The tomato growers there don't need drip irrigation."

These factors mean that the costs of production are lower for the competition than they are for Florida growers. Taylor says that because of higher yields and excellent quality, East Coast tomato growers can compete with California. Also, close proximity to the market saves on transportation costs.

"Quantity and quality are our two major advantages. And they are a direct result of our using methyl bromide," Taylor says. "Yes, it is possible for us to grow tomatoes with some of the proposed alternatives. However, we probably cannot grow enough of a quality crop to cover the costs of production."

According to Taylor, "Losing methyl bromide will take away the competitive edge that Florida tomato growers have enjoyed and that has kept us in business for decades."

Plant Mulches: Possible Methyl Bromide Alternative?

With only two full crop seasons remaining before the ban on the use and importation of methyl bromide in the United States, Government policy officials and researchers, industry, academia, and growers are leaving no stone unturned in the frantic search for alternatives. Vegetable growers and others are sounding the alarm that if no viable alternatives surface soon, they may go belly-up. So far, there is no commercially available alternative that does as good a job for growers as this soil fumigant.

The heat is on at USDA's Agricultural Research Service to exhaust all possibilities in finding some alternative that will ease growers' reliance on this chemical that for decades has been so effective in eliminating soilborne pests and diseases and ensuring high, quality yields.

Aref Abdul-Baki, a plant physiologist with ARS' Vegetable Laboratory in Beltsville, Maryland, has been growing vegetables with plant mulches for almost 10 years. He has worked with growers in

Maryland, Virginia, and Pennsylvania who raise strawberries, squash, beans, corn, cantaloupes, peppers, and tomatoes. These growers have adopted the practice of plant mulches and have increased their yields and decreased production costs by using less fertilizer and less chemicals to control pests, disease, and weeds.

"I started with tomatoes," Abdul-Baki says, "And used hairy vetch instead of the traditional black polyethylene mulch. The idea is simple: plant a cover crop in the fall, mow it to about two to three inches in the spring, then immediately plant tomatoes without disturbing the soil."

Abdul-Baki followed a four-year crop rotation system in his test plots. The first year, he planted fresh-market tomatoes, followed by a cover crop of hairy vetch. The second year, he introduced a mixture of hairy vetch and crimson clover. Each year since then, he used a mixture of hairy vetch, crimson clover, and rye on the crops. He planted sweet corn the second year, followed by muskmelons the third, and snapbeans the fourth.

"Cover crops are planted in the fall after harvesting the vegetables and are cut in May the following year," he says. Granted, plant mulches add organic matter to the soil and increase its water-holding capacity, and they even add nitrogen, all of which help boost plants' productivity. But what about pests and weeds?

Pests

David Chitwood, head of the ARS Nematology Lab in Beltsville has compiled some data on nematode populations from Abdul-Baki's experimental plots.

"We found no increase in the numbers of nematodes in the test plots," Chitwood reports. "But we don't have a problem with root-knot nematodes in the area containing Abdul-Baki's plots."

Chitwood's lab monitored populations of five phytoparasitic nematodes: root-knot, lesion, stunt, spiral, and lance. Nematode numbers started low early in the growing season and remained below the levels that could cause economic losses through harvest.

Scientists were concerned about the numbers of nematodes in the soil because certain legumes, including hairy vetch, are somewhat susceptible hosts of nematodes. Therefore, under favorable conditions, numbers may increase, especially if cover-crop legumes are part of the crop rotation system.

"The cold winters here in the mid-Atlantic region could have played a part in this scenario," Chitwood says.

Weeds

John Teasdale, a plant physiologist in the ARS-Beltsville Weed Science Lab has collaborated with Abdul-Baki since 1991. "Some cover crops make such a heavy, matted mulch that it actually suppresses early-season weeds, eliminating the need for preplant herbicides," he says.

Generally, cover crops delay weed growth, but they don't completely control weeds, Teasdale reports. "Some other type of practice is usually necessary to control postemergence weeds. Plant mulches reduce the number of weeds by the sheer biomass of the cover crop residue. Using hairy vetch alone to grow vegetables doesn't provide enough plant material to adequately suppress weeds. That's why we use mixtures of vetch with crimson clover and rye."

Legumes like hairy vetch decompose quickly, adding more nitrogen to the soil. However, the rapid decomposition reduces the mulch biomass needed to help keep weed emergence at a minimum.

Several vegetable crops, including tomatoes, corn, beans, melons, and peppers have been grown with plant cover crops. "We've successfully slowed down the emergence of pigweed, lambsquarters, and foxtail—three weed species that plague these vegetable crops," Teasdale reports. "We found that small-seeded annual weeds tend to be the ones that are suppressed most by plant cover crops."

Matted plant mulches allow crops to become established and growers to identify what weeds emerge so that appropriate herbicides can be applied later in the growth cycle. Crops like peppers, which don't have a dense leaf canopy, don't fare as well as crops that produce enough cover to shade the emerging weeds.

"We feel that cover crops can be one piece of the puzzle for an integrated approach to the loss of methyl bromide," Teasdale says.

Future Plans

Some of the leading growers in Florida have said that unless a practical technology is developed soon which can effectively replace methyl bromide, commercial vegetable production may collapse in the subtropical area of southern Florida.

Would the idea of plant mulches work in a different environment such as the climate in Florida and perhaps be a potential alternative to methyl bromide for vegetable growers there? Well, Abdul-Baki may get a chance to see.

Waldemar Klassen, director of the University of Florida's Tropical Research and Education Center in Homestead, has invited Abdul-Baki to try his method on research fields in Florida.

"We've been looking at Abdul-Baki's research for some time," Klassen says. "We have several research projects on methyl bromide under way at Homestead. Also, we have a highly promising project on the legume sunn hemp that was inspired by ARS research at Auburn, Alabama, and another on perennial peanut sources. However, we haven't worked on plant mulches and are most anxious to collaborate with ARS to investigate the suppressive effects of mulches on soilborne pathogens that thrive in the unusual calcareous soils of the south Florida winter vegetable production area. Since south Florida soils are very different from those at Beltsville, Maryland, we need to work together to develop a practical technology in the short time we have left before Florida vegetable growers are denied the use of methyl bromide."

ARS Update: Controlling Weeds and Soilborne Pests—Ft. Pierce, Florida

As detailed in the April 1998 issue of *Methyl Bromide Alternatives* (pp. 5–7), ARS has increased research efforts on finding methyl bromide alternatives at the new Fort Pierce, Florida, location. A new position of soil microbiologist established there was recently filled by Richard Shelby, who came from Auburn University. In April, weed scientist Erin Rosskopf replaced David Patterson, who retired from ARS in March 1998. Rosskopf discovered a new species of fungi that controls pigweeds, which are considered one of the world's worst weeds for many crops.

Roy McDonald, ARS research leader based at Orlando, Florida, is responsible for the methyl bromide work at Fort Pierce. "We needed someone to look into problems dealing with fungi, bacteria, nematodes, insects, and weeds. Shelby will characterize soil microbes that benefit plant health by restricting the ability of soilborne pests to affect crops. He'll also help develop ecologically sound, biologically based integrated disease and pest management strategies for tomatoes, peppers, and other vegetables. Rosskopf will deal with weeds."

Addressing Soilborne Problems

Specifically, Shelby was hired to identify soil microbes tht affect both the survival and the ability of soilborne pathogens to cause disease in vegetable and small fruit production systems.

"Since my background is mainly in mycology, I'll probably focus on fungi endemic in the area, like Fusarium wilt, Fusarium crown rot, and southern blight," Shelby says. "Several biologically based methods have been suggested that might control these pathogens. For instance, nonpathogenic strains of *Fusarium* appear to elicit a systemic acquired resistance to strains that are pathogenic."

He plans to search for these nonpathogenic strains and others that produce resistance or that are antagonistic to plant pathogens. "I plan to develop molecular methods to identify and trace the movement of these organisms after they've been introduced to plants."

As a broad spectrum fungicide, methyl bromide controls many diseases and pests. However, Shelby's approach will target specific soil pests with specific biological pesticides.

Soil amendments have been effective in reducing the incidence of some soilborne plant pathogens. Shelby also expects to explore these, using waste products local to Fort Pierce, such as paper mill and citrus wastes.

Controlling Weeds

Weed scientist Erin Rosskopf came to ARS-Fort Pierce from the University of Florida. She brought with her a biological agent that controls pigweeds and amaranths. Rosskopf is co-owner of a patent for the agent, which is a new species of fungi belonging to the genus *Phomopsis* Bubák. She will test the new agent—*P. amaranthicola*—against weeds that

will be significant when methyl bromide is banned in 2001.

"We identified this fungal species as the causal agent of a leaf and stem blight that occurs on *Amaranthus* in Florida," Rosskopf says. "Pigweeds and amaranths belong to this genus. They're broadleaf plants that are primarily herbaceous annuals, although there are a few woody species."

According to Rosskopf, these types of plants thrive in climates with high temperatures, intense sunlight, and dry conditions, although they're also commonly found anywhere that the soil has been disturbed and is not excessively wet.

"In Florida, pigweeds are included in the ten most commonly found weeds in tobacco, soybeans, cotton, and peanuts," Rosskopf says. "Not only do these tenacious weeds compete with crops, but they can also poison livestock. In areas where herbicide use is limited by choice, such as in organic production areas, pigweeds can render the land virtually unusable."

Pigweeds, she says, have caused corn yield losses as high as 40 percent and may also dramatically reduce cotton yields.

"In a potato field, a single redroot pigweed plant per meter of row has caused up to 32 percent loss of marketable tubers," Rosskopf reports.

Smooth pigweed—*Amaranthus hybridus*—is a principal problem in crops like peas, sugar beets, sugarcane, potatoes, wheat, and soybeans. It is an agronomic pest in 27 countries, including the United States, Brazil, Argentina, New Zealand, and Mexico.

Spiny amaranth or *Amaranthus spinosus* L., affects several valuable crops such as tobacco, cotton, cassava, upland rice, mangoes, sorghum, sweet potatoes, and papayas. This weed is most troublesome in tropical and subtropical regions and causes problems in more than 40 countries, including the United States, Brazil, Taiwan, and Thailand.

Redroot pigweed (*A. retroflexus*) is also a serious weed problem in many countries, as are other species. Various types of pigweed constitute the worst of all weed problems in Puerto Rico where they affect many fruit crops, beans, and garlic.

"Traditionally, triazine herbicides have been extremely effective in controlling pigweeds, but the herbicides' persistence in the soil and highly specific mode of action have resulted in many resistant populations," Rosskopf reports. "And although there are registered herbicides that control pigweeds on major crops, there are problems associated with their use. These problems include nontarget effects and toxicity."

Rosskopf has a cooperative project with the University of Florida (UF) to evaluate the fungus *Dactylaria higginsii* for controlling purple and yellow nutsedge. Her collaborator on this project is R. Charudattan of UF's Institute of Food and Agricultural Science. Purple nutsedge is considered the world's worst weed. It is extremely troublesome to Florida's raised-bed, plastic mulch pepper and tomato production systems.

"This fungus reduces the competitive ability of nutsedges," Rosskopf says. "Some plastic mulches and soil solarization suppress this weed somewhat. We want to combine *D. higginsii* with these practices to see if we can get better control."

Rosskopf and Charudattan are studying the conditions necessary for large-scale application, as well as what form of the organism would be compatible with current cropping practices. They plan large-scale field testing this fall.

Another weed that Rosskopf will study is *Portulacca oleraceae*, which is also a problem in most crops produced in Florida using raised-bed plastic mulch production systems. "We're looking at the fungus *Dichotomophthora portulacae* as a potential biocontrol agent. Lab and greenhouse trials are under way to find the conditions necessary to produce the fungus and those needed for high field efficacy," she says. "We'll do field tests with our next tomato and pepper crops."

Rosskopf is testing all of these organisms for compatibility with chemical pesticides, both for ease of application and to determine possible synergistic effects.

"Part of my mission is to test some of the alternatives developed by other scientists for weed control. Also, there is a need to characterize pathogens associated with weeds. For example, root-knot nematodes are often found on nutsedge tubers. How will this affect the crop if methyl bromide is not around to control nutsedge?"

With the proposed ban on methyl bromide only a couple of crop seasons away, more data are

urgently needed on weeds. A future area of research will focus on fungal plant pathogens associated with weeds that may also affect crop health. Weeds are often thought to harbor crop pests. “Beginning with the next cropping period, I’ll characterize the fungal pathogens found on weeds growing in tomato and pepper fields,” Rosskopf says. “Controlling weeds must play a vital role in our efforts to find alternatives to methyl bromide.”

Technical Reports

The Impact of Methyl Bromide Alternatives in Tomato on Double-Cropped Cucumber

J. P. Gilreath and J. P. Jones, University of Florida, Gulf Coast Research & Education Center, Bradenton, FL 34203 and J. W. Noling, University of Florida, Citrus Research & Education Center, Lake Alfred, FL 33850.

Most of the methyl bromide alternatives research in Florida has focused on identifying viable alternatives in tomato or some other primary crop, but often that is only half the picture for many tomato growers. The economics of tomato production are such that many growers have adopted a production strategy which spreads the cost of soil fumigation and fertilization over two crops for the farm to remain profitable.

This is achieved by killing the first crop at the end of the season and leaving the raised, polyethylene film mulched beds in place, undisturbed and then growing a second crop on them. Thus, the residual fertilizer is utilized and the cost of soil fumigation, mulch and, in some cases, microirrigation tubing is spread over two crops. This procedure of growing a second crop using the inputs for the previous fumigated crop, is referred to as double-cropping. The first crop is usually tomato, but may include pepper, and the second crop is typically a cucurbit, such as cucumber or watermelon. Cucurbits are favored because they are cheaper to grow and are not in the same botanical family as tomato, thus avoiding some potential disease problems.

Previous work by the authors and other members of the Florida Methyl Bromide Alternatives Task Force has determined that the most likely chemical replacement for methyl bromide in tomato will be a combination of Telone C–17 or C–35 soil fumigant and Tillam herbicide. The effectiveness of this alternative has been demonstrated in both small plot research and large plot trials on commercial farms. Although sometimes not as effective as methyl bromide for soilborne pest control, including nutsedge control, this combination generally has performed quite well. Cooperating tomato growers indicate that the mechanics of application would be acceptable.

One concern that has plagued this and all alternatives research is the fact that most research is being done on sites which received methyl bromide in previous years. Another concern expressed by growers has been what impact the combination might have on double cropped cucurbits. Their concern involves herbicide residues in the bed and resurgence of soilborne pests, such as root knot nematode. Cucurbits are well known for their sensitivity to herbicides and there are few herbicides labeled for their use. Tillam is not one of those. In some experiments, Telone C–17 or C–35 has controlled root knot nematodes as well as methyl bromide, statistically speaking, but the absolute number of nematodes present or the extent of galling might be slightly higher. Growers fear that these slightly higher numbers might translate into significantly higher incidence and severity in the double crop.

To address the issue of residual activity of Tillam, we conducted experiments over the past several years at the Gulf Coast Research and Education Center to determine the effect of Tillam on cucumber growth when grown in the same beds following tomato and soil fumigation with methyl bromide, chloropicrin, Vapam, or Telone C–17 or C–35. Some of these studies also were designed to assess the impact of the previous season’s soil fumigation program on overall growth of cucumber and root knot nematode populations that develop on the cucumber roots.

The time interval between Tillam application for tomato and cucumber planting is the shortest in the spring. Conditions during the fall season and over the brief winter period prior to cucumber planting are less conducive to herbicide degradation than following a spring tomato crop. For these reasons, we conducted the Tillam studies in the spring following a fall tomato crop. Results of these and related studies indicate that the level of Tillam remaining in the bed at the time of cucumber planting is not sufficient to cause any damage to cucumber.

The resurgence of root knot nematodes was determined in both fall and spring double cropped cucumbers. Late season nematode

resurgence was a problem even with methyl bromide, but it was a bigger problem with the alternative fumigants. Root galling due to root knot nematodes was worse on the fall cucumber crop. Root galling at the end of the crop season was greater with methyl bromide in the spring than with some of the other fumigants, but the plants were more vigorous. A more vigorous plant has a larger root system which can sustain higher nematode populations. Fumigation with Vapam, chloropicrin or Telone C–17/C–35 resulted in more vigorous plants, higher yields, and less root galling than no fumigation, but in general they were not as effective as methyl bromide.

Thus, it appears that none of the fumigant alternatives will be as effective as methyl bromide when viewed in a double crop scenario. Research is continuing on this and related topics.

Trapping/Destroying Methyl Bromide on Activated Carbon Following Commodity Fumigation

James G. Leesch, research entomologist, USDA–ARS, Horticultural Crops Research Laboratory, Fresno, CA 93727 and Gerhard F. Knapp, chemical engineer and President of GFK Consulting Ltd., San Clemente, CA

Methyl bromide is an extremely useful fumigant for the disinfestation of perishable and durable commodities prior to sale either in the domestic market or abroad. For years it has formed the backbone of the U.S. fight against the introduction of unwanted pests into this country or exporting unwanted pests to other countries on our commodities. It forms the basis for lifting export bans against quarantine insects in many countries around the world and is largely responsible for our ability to export commodities to partner nations. As it stands now, methyl bromide will be withdrawn from use and production on January 1, 2001 in the United States, as mandated by the Clean Air Act. USDA's Agricultural Research Service (ARS) has been heavily involved since 1994 in finding alternatives to methyl bromide because of its importance in U. S. agriculture. It has been estimated that the loss of methyl bromide without alternatives would amount to a loss in California alone of between $300 and $400 million in exports.

With this in mind, in 1995, ARS, along with a private cooperator, GFK Consulting Ltd., began conducting research on capturing methyl bromide on activated carbon so that, following commodity fumigation, little or no methyl bromide gas would escape to the atmosphere. Of course, the use of this system is based on the possibility that some legislative adjustments will be made to the Clean Air Act so that methyl bromide will be available for use in commodity pretreatment or quarantine situations beyond the 2001 deadline now imposed by the Act. In 1997, Great Lakes Chemical Corporation joined the cooperative research and development agreement (CRADA) in order to transfer the technology into practical uses within the agricultural community.

Research to date has identified the most favorable type of carbon for the sorption of methyl bromide as well as the best conditions for the sorption. Activated carbon derived from coconut shells has proven to sorb more methyl bromide than that derived from either coal or peat. The sorption of methyl bromide has been found to be inversely proportional to both the temperature and humidity of the gas stream containing the methyl bromide. Typical loading of the carbon with methyl bromide runs from 8 percent to 14 percent (grams of methyl bromide per 100 grams activated carbon) under the concentration and flow conditions commonly found in agricultural commodity fumigations. Recent research has also shown that carbon used to adsorb methyl bromide following desorption of previously sorbed methyl bromide, is most effective when the desorption, or regeneration, process is carried out at high rather than low temperature.

In conducting the research, we paid particular attention to designing the system to fit procedures presently used in typical commodity fumigations. When a fresh commodity, such as plums, grapes or cherries, is fumigated, it is very important to remove the methyl bromide quickly following the fumigation because many such fresh commodities are damaged by over-exposure to the fumigant. Typically, aeration fans remove 10 percent to 15 percent of the volume under fumigation per minute. Therefore, concentrations of methyl bromide go from very high (i.e., 15,000 ppm) to low concentrations (i.e., 500 ppm) in about 30 minutes. The adsorption unit has been tested both in the laboratory and in pilot versions using an initial concentration of 64 milligrams per liter (about 16,000 ppm) and an air flow through the carbon bed that was based on a 10,000 cubic feet per minute ventilation rate taken from a 72,000 cubic foot chamber.

To date, testing has shown that from 8 percent to 14 percent loading (grams MB per 100 grams activated carbon) of the activated carbon is common over a wide variety of temperatures and humidities. In addition, repeated use of carbon for capturing methyl bromide showed that volatiles from oranges had no effect on the amount of methyl bromide sorbed during each trapping cycle.

The desorption of the methyl bromide after each trapping cycle and the reactivation of the carbon can be carried out at a centrally located reclamation facility to which the carbon container with the methyl bromide on carbon can be shipped. The methyl bromide is desorbed from the spent carbon and thermally oxidized. The process yields sodium bromide which can then be recycled back into the chemical industry. In the process of desorbing the methyl bromide, the carbon is reactivated and returned to a container for reuse in capturing more methyl bromide.

Recently, a pilot unit was built to conduct tests on actual commodity fumigations. The pilot unit was first tested in 1997 at Valley Fig Growers in Fresno, California, and subsequently on Kiwi fruit in the Port of San Pedro as well as several sites on the eastern seaboard. In most of these tests, only a portion of the effluent stream of fumigant-ladened gas from the chamber was diverted to the pilot unit. However, at two sites, the entire fumigant stream from the chamber was diverted through the unit. During a tarpaulin fumigation of yams from Costa Rica, 83 percent of the methyl bromide used was trapped on the carbon. The reduction of methyl bromide in the vent stream for this type of fumigation will exceed 95 percent.

Today, methyl costs about $2 per pound. We estimate about $15 per pound would cover the methyl bromide, the transport of the container with carbon to the fumigation site, and removal of the container when the carbon is expended. The fumigation facility would be responsible for providing a fan to pull the exhaust gas through the ducting and carbon container and for the ducting to link the container to the fumigation chamber. The cost is a seven fold increase based on methyl bromide. However, based on a 72,000 cubic foot chamber that holds 51,000 flats of grapes, for example, that cost represents only an increase of seven cents in a flat of grapes.

The activated carbon removes all the methyl bromide from the exhaust stream until the carbon becomes saturated. The capture system is capable of removing 95 percent of the available methyl bromide from the fumigation facility. Evacuating more fumigant is possible but not practical because so much activated carbon is wasted collecting concentrations below 500 ppm. The capture unit could trap methyl bromide from any commodity fumigation being conducted either in a chamber, indoors under a tarpaulin, or in any sealed structure. The first commercial units for methyl bromide capture should be available in early 1999.

Upcoming Meetings

Orlando, Florida—December 7–9, 1998

The Annual International Research Conference on Methyl Bromide Alternatives and Emissions Reductions will be held December 7–9, 1998, at the Omni Rosen Hotel in Orlando, Florida.

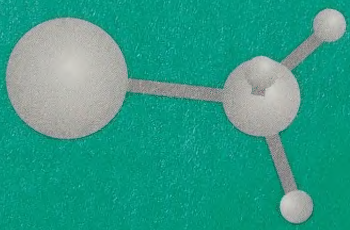
As in previous years, the Methyl Bromide Alternatives Outreach is sponsoring the conference in cooperation with the Crop Protection Coalition, the U.S. Department of Agriculture, and the U.S. Environmental Protection Agency.

For more information, contact Anna Williams, Methyl Bromide Alternatives Outreach, 144 W. Peace River Drive, Fresno, CA 93711–6953; phone (209) 447–2127; fax (209) 436–0692; e-mail, gobenauf@concentric.net. Participants may register on the Internet: **http://www.gov/ozone/mbr/altmet98.html**

Conference participants must make their own hotel reservations. A reduced conference room rate will be available through November 6. The Omni Rosen Hotel is located at 9840 International Drive, Orlando, FL 32819–8122, phone (407) 354–9840, fax (407) 351–2659. Toll-free number is (800) 800–9840. Again this year, four 2-hour sessions are planned for specific topics. The number of presentations will be limited for these sessions because a discussion period will follow each.

Focus of the conference will be to:

- Evaluate the technology transfer process and incentive programs needed to implement alternatives,
- Discuss problems associated with implementing potential alternatives,
- Enhance scientific information and data exchange on methyl bromide alternatives research,
- Provide a forum to exchange interdisciplinary scientific and agricultural information,
- Develop and distribute conference proceedings as a state-of-the-art methyl bromide alternatives source for researchers, users of methyl bromide, legislators, government policy officials, and the general public,
- Support data gathering on potential alternatives to methyl bromide for future evaluation and prioritization,
- Monitor development of viable alternatives to methyl bromide.



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